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Developing Creative Problem Solving Abilities and Related Attitudes Through Programed Instruction*

One very important aspect of the educator's concern for creative thinking and problem solving can be seen in the question, "Can creative problem solving abilities be developed in pupils through instruction?" An interesting attempt to answer this question is represented by a set of instructional materials called the *Productive Thinking Program*, developed by the Berkeley Creativity Project at the University of California (Covington, Crutchfield, and Davies, 1966). These materials seek to develop creative problem solving abilities and related attitudes among elementary school pupils (Crutchfield and Covington, 1965).

In addition to its practical appeal for teachers and administrators, the PTP is also of potential value for the researcher studying training in creative thinking and problem solving. Although the materials were not derived from any particular theoretical position, they appear to be a unique attempt to translate general ideas about creative problem solving into an instructional program. As such, they may be valuable in a variety of classroom research settings.

From July 1967 through the summer of 1968, the writers, as directors of the Elementary School Creativity Project at Cornell University, conducted a program of research and demon-

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stration in which these materials were utilized. Technical reports of this research are available (Treffinger and Ripple, 1968), but the correspondence between the objectives of the project and the goals of the Creative Education Foundation has led us to prepare this summary report as well.

PREVIOUS
RESEARCH

Covington and Crutchfield (1965) reported results of two studies, in which the programmed instructional materials were used with fifth- and sixth-grade pupils. Instructed pupils' performance on a number of problem solving criteria was far superior to that of uninstructed pupils. The results, however, were more pronounced for fifth-graders than for sixth-graders. Ripple and Dacey (1967) used an abbreviated experimental version of the instructional program with eighth-grade pupils. In that study, there were no significant differences between instructed and control pupils on creative thinking measures. Instructed pupils did solve the Maier two-string problem significantly faster than control pupils. Olton *et al.* (1967) studied fifth-grade pupils. They found that instructed pupils performed significantly better than controls on eleven of forty creative problem solving criteria.

THE RESEARCH
PROBLEM

Several specific questions were addressed by this research. These included:

1. What effects, if any, will studying the *Productive Thinking Program* have on pupils' scores on tests of verbal creative thinking abilities?
2. What effects, if any, will the instructional program have on pupils' ability to solve a number of verbal and insight problems presented in paper and pencil format?
3. What effects, if any, will the instructional program have on pupils' ability to solve arithmetic problems? (That is, will there be transfer from the general, mystery-problem format of the instructional materials to problem solving in a traditional subject matter content?)
4. What effects, if any, will the instructional program have on pupils' attitudes about creative problem solving?

Since previous research has suggested that the programmed instructional materials may be differentially effective with pupils at different age levels (Ripple and Dacey, 1967), this study included four grade levels. Pupils were studied from grades four through seven; results were analyzed at *each* of the four grade levels.

PROCEDURES

Three hundred seventy pupils from 16 classes participated in the study. There were four classes at each of the grade levels studied. At each grade level, two classes were randomly as-

signed to the *instructional* condition; the pupils in the other two classes served as *controls*. There were no significant differences between the experimental and control groups with respect to verbal intelligence test scores, and sex, reading, and socio-economic status distributions.

All pupils were then tested on verbal creativity, using the Torrance Tests of Creative Thinking, Verbal Form A (Torrance, 1966), and on a test which assessed arithmetic computation skills.

Immediately following the pretesting period, the use of the programmed instructional materials was begun in experimental classes. Pupils in these classes studied the programmed lessons, one booklet per day, for 16 consecutive school days. Each pupil worked independently on each booklet, and at his own pace. Control pupils received only their ordinary classroom instruction.

After the conclusion of the 16 lessons for instructed pupils, all pupils were given a battery of creative problem solving measures. These included: the Torrance Tests of Creative Thinking, Verbal Form A (Torrance, 1966); the Childhood Attitude Inventory for Problem Solving (Covington, 1967); and two of three problem solving measures constructed for the study. All pupils received a General Problem Solving test; each pupil received one of two forms of an Arithmetic Problem Solving test (a Puzzles form or a Text Problems Form). The validity and reliability of these instruments has been discussed in detail by Treffinger and Ripple (1968). For the present purposes, let us indicate that only the rather difficult Arithmetic Puzzles test had limited reliability (Kuder Richardson Formula 20 reliability coefficient = .49). In general, the measures were considered valid for research utilization.

ANALYSES

Verbal creativity scores of instructed and control pupils were compared using analysis of covariance. The pupils' pretest scores and their IQ scores were covaried. That is, the comparison of pupils' posttest creativity scores took into account initial differences on creativity and IQ.

Since each of the problem solving tests contained tasks which could be scored in one of two ways, two kinds of analyses were conducted. First, several problems were scored dichotomously; that is, the pupil either solved the problem, or he did not. For such scores, it is appropriate to use a Chi-square test to compare the *proportion* of instructed pupils who solved the problem with the proportion of control pupils who solved it. Then, for the total number of solutions each pupil obtained, and for problems which were scored continu-

ously rather than dichotomously, mean scores of instructed and control pupils were compared using analysis of covariance. Since it was considered important to take IQ and, for arithmetic problems, the pupils' arithmetic pretest scores into consideration, these scores were used as covariates. Then, instructed and control pupils' attitude scores were compared using analysis of variance.

RESULTS

There were no significant differences between the instructed and control pupils' mean scores on the verbal creativity tests, when initial differences on IQ and pretest were controlled. This result was obtained for all creativity sub-test scores and for standardized total scores, at all four grade levels.

Also, there were no significant differences between instructed and control pupils' performance on either of the Arithmetic Problem Solving tests, at any of the four grade levels.

For the General Problem Solving test, there were five significant differences between the instructed and control pupils' scores, of forty comparisons made. Of those five differences, three favored the instructed pupils. In grade four, instructed pupils' mean scores were significantly greater than controls' only for a paper and pencil anagram problem. In grade five, instructed pupils' mean scores were significantly greater than controls' on the anagram problem and on a modified version of the Pea Problem (Raaheim, 1962). In grades six and seven, there were no significant differences between instructed and control pupils' scores on any of the problems.

TABLE 1
Pupil Attitude Inventory Comparisons
By Grade Level

<i>Grade—Section of Inventory¹</i>	<i>Instructional</i>		<i>Control</i>		<i>F(df)</i>	<i>P</i>
	<i>Mean</i>	<i>N</i>	<i>Mean</i>	<i>N</i>		
4 Part I	17.02	47	14.75	52	10.64(1,97)	<.01
Part II	12.84	45	12.64	45	<1	n.s.
Total Score	30.07	45	27.64	45	4.07(1,88)	<.05
5 Part I	18.84	44	15.05	38	12.96(1,80)	<.01
Part II	14.19	36	12.59	32	3.63(1,66)	n.s.
Total Score	32.89	36	27.91	32	9.79(1,66)	<.01
6 Part I	19.81	48	16.62	42	11.63(1,88)	<.01
Part II	13.44	48	13.84	37	<1	n.s.
Total Score	33.25	48	30.35	37	4.27(1,83)	<.05
7 Part I	22.93	41	19.30	44	16.69(1,83)	<.01
Part II	12.08	40	12.05	44	<1	n.s.
Total Score	34.95	40	31.35	44	6.42(1,82)	<.025

¹Maximum Possible Scores: Part I=30; Part II=22; Total=52.

For the Childhood Attitude Inventory for Problem Solving, there were significant differences between the instructed and control pupils' scores at all four grade levels. These results are summarized in Table 1. At all four grade levels, instructed pupils' mean scores were significantly greater than control pupils' scores on Part One (general attitudes about creative thinking and problem solving), and on Total Score.

DISCUSSION

The results of this study offered no support for the effectiveness of the instructional materials with respect to the development of pupils' verbal creative thinking abilities, at any of the four grade levels reported. This result is consistent with results reported by Ripple and Dacey (1967), with eighth-grade pupils. Also, Olton *et al.* (1967) found that instructed fifth-graders did not differ significantly from control pupils on similar tasks.

It should also be noted that the results of this study did not provide any evidence for transfer from the instructional materials to arithmetic problem solving. The authors of the instructional program proposed that the skills, abilities, and attitudes developed in the instructional sequence would transfer to a variety of traditional subject-matter problem solving tasks. We were unable to provide support for that proposition. Although our problem solving measures were difficult, and the reliability of the Puzzles test was lower than desirable, the tests *did* provide examples of the kinds of problem solving in arithmetic which elementary school pupils typically confront. Thus, the criteria may have been rigorous, but they were not irrelevant.

Further, there was no strong support for the effectiveness of the instructional materials with respect to verbal and insight problem performance, although some differences between instructed and control pupils reached significance on these problems.

Although all attempts to understand these results are speculative, there are several interesting possibilities. First, the materials were used without teacher participation or involvement. Secondly, they were presented in a rapid sequence: one lesson on each of 16 consecutive school days; third, no supplementary practice or discussion was provided to relate the instruction to other aspects of the pupils' experience. As Olton *et al.* (1967) have pointed out, such conditions certainly provide a severe test of the effectiveness of the instructional materials. It would seem likely that, under less demanding conditions, there would be a greater impact on pupils' creative problem solving.

The significant differences between instructed and control pupils, at all grade levels, on the attitude inventory suggests that the instructional materials did have a measurable impact on instructed pupils. In interpreting this result, the findings from another recent study (Tuckman, Henkelman, O'Shaughnessy, and Cole, 1968) are of considerable interest. They found that subjects became less able to apply what they had learned in a problem solving training procedure as test problems became increasingly dissimilar from training problems. Further, they warned that instructional programs may have the effect of developing pupils' ability to attempt to use their training, yet leave them unable to successfully apply the training to new problems. In our study, where criterion measures were generally difficult and were not presented in the same format as the problems in the programed lessons, exactly this phenomenon may have occurred. The pupils may have been influenced by the instructional materials, as reflected in the differences on the attitude inventory, but, when confronted with difficult problem solving tasks, in a new format, may have been unable to apply successfully the training they had received.

Our results certainly point to the importance of the active involvement of the teacher in the learning situation, particularly in the development of complex cognitive skills such as creative problem solving, and even when programed instructional materials are provided for the pupils.

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SUMMARY The application of Functional Visualization can result in creative solutions to broadly defined problems. It curtails the natural tendency to view solutions as they appeared traditionally. The Functional Visualization is accomplished by first visualizing the performance of needed functions without the use of hardware, occurring as if by magic. Then, necessary hardware is added very gradually through creative interpretation until a completed solution emerges. Because of its conceptual nature, this approach also enables existing creative techniques such as brainstorming, checklists, and bionics to be utilized more successfully.

Functional Visualization involves picturing function being accomplished. Thus, the development of a design requires sketches or drawings rather than words. Functional Visualization can be thought of as a system by which a series of evolving pictures is translated, sketch by sketch into a complete design.

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